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December 20, 2006

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Re: Title: VISIBLE SPECTRUM MODULATOR ARRAYS
Letters Patent No. 7,126,738
Issued: October 24, 2006
Our Reference: IRDM.025CCD

Dear Sir:

Enclosed for filing is a Certificate of Correction in connection with the above-identified patent. Also enclosed are the cover page and the page containing Columns 1 and 2 of the above identified patent. It is evident that item (60) on the cover page of the patent is missing the related application No. 09/413,222 listed in Column 1, lines 10-12.

As the errors cited in the Certificate of Correction were incurred through the fault of the Patent Office, no fee is believed to be required. However, please charge our Deposit Account No. 11-1410 for any fees that may be incurred with this request.

Respectfully submitted,

Knobbe, Martens, Olson & Bear, LLP

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Enclosures

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UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 7,126,738

APPLICATION NO. : 10/082,397

ISSUE DATE : October 24, 2006

INVENTOR(S) : Mark W. Miles

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Item (60) should read:

Division of application No. 09/378,143, filed on Aug. 20, 1999, now abandoned, and continuation of application No. 09/413,222, filed on Oct. 5, 1999, which is a continuation-in-part of application No. 08/744,253, filed on Nov. 5, 1996, now U.S. Pat. No. 5,986,796, which is a continuation of application No. PCT/US95/05358, filed on May 1, 1995.

MAILING ADDRESS OF SENDER:

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DOCKET NO. IRDM.025CCD

US007126738B2

(12) **United States Patent**
Miles

(10) **Patent No.: US 7,126,738 B2**
(45) **Date of Patent: Oct. 24, 2006**

(54) **VISIBLE SPECTRUM MODULATOR ARRAYS**

(75) Inventor: **Mark W. Miles**, San Francisco, CA (US)

(73) Assignee: **IDC, LLC**, San Francisco, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **10/082,397**

(22) Filed: **Feb. 25, 2002**

(65) **Prior Publication Data**

Related U.S. Application Data

(60) Division of application No. 09/378,143, filed on Aug. 20, 1999, now abandoned, which is a continuation of application No. 08/744,253, filed on Nov. 5, 1996, now Pat. No. 5,986,796, which is a continuation of application No. PCT/US95/05358, filed on May 1, 1995.

(51) **Int. Cl.**
G02F 1/07 (2006.01)

(52) **U.S. Cl.** **359/245**; 359/247

(58) **Field of Classification Search** 359/245–247, 359/249, 315–317

See application file for complete search history.

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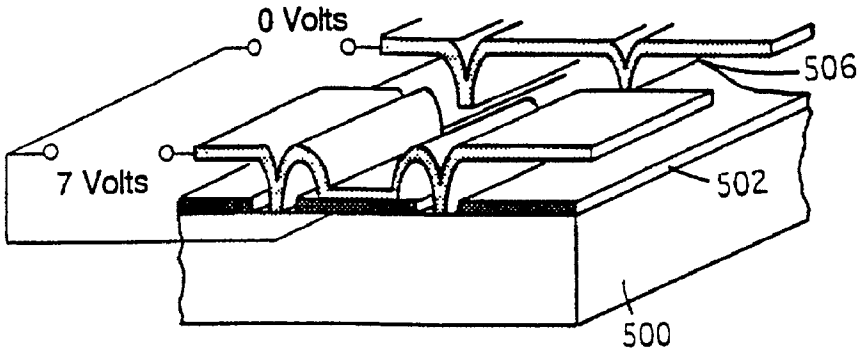
(57) **ABSTRACT**

Light in the visible spectrum is modulated using an array of modulation elements, and control circuitry connected to the array for controlling each of the modulation elements independently, each of the modulation elements having a surface which is caused to exhibit a predetermined impedance characteristic to particular frequencies of light. The amplitude of light delivered by each of the modulation elements is controlled independently by pulse code modulation. Each modulation element has a deformable portion held under tensile stress, and the control circuitry controls the deformation of the deformable portion. Each deformable element has a deformation mechanism and an optical portion, the deformation mechanism and the optical portion independently imparting to the element respectively a controlled deformation characteristic and a controlled modulation characteristic. The deformable modulation element may be a non-metal. The elements are made by forming a sandwich of two layers and a sacrificial layer between them, the sacrificial layer having a thickness related to the final cavity dimension, and using chemical (e.g., water) or a plasma based etch process to remove the sacrificial layer.

20 Claims, 36 Drawing Sheets



VISIBLE SPECTRUM MODULATOR ARRAYS

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a divisional application of U.S. Ser. No. 09/378,143, filed on Aug. 20, 1999 (now abandoned). The disclosure of the prior application is considered part of, and is incorporated by reference in, the disclosure of this application. This application is also a continuation of co-pending U.S. patent application Ser. No. 09/413,222, filed Oct. 5, 1999, which is a continuation-in-part of U.S. patent application Ser. No. 08/744,253, filed Nov. 5, 1996 (now U.S. Pat. No. 5,986,796), which is a continuation of International Application PCT/US95/05358, filed May 1, 1995. The disclosure of U.S. patent application Ser. No. 08/744,253 (now U.S. Pat. No. 5,986,796) is considered part of, and is incorporated by reference herein. The disclosure of International Application PCT/US95/05358 is considered part of, and is incorporated by reference herein.

BACKGROUND

This invention relates to visible spectrum (including ultraviolet and infrared) modulator arrays.

Visible spectrum modulator arrays, such as backlit LCD computer screens, have arrays of electro-optical elements corresponding to pixels. Each element may be electronically controlled to alter light which is aimed to pass through the element. By controlling all of the elements of the array, black and white or, using appropriate elements, color images may be displayed. Non-backlit LCD arrays have similar properties but work on reflected light. These and other types of visible spectrum modulator arrays have a wide variety of other uses.

SUMMARY OF THE INVENTION

In general, in one aspect, the invention features modulation of light in the visible spectrum using an array of modulation elements, and control circuitry connected to the array for controlling each of the modulation elements independently, each of the modulation elements having a surface which is caused to exhibit a predetermined impedance characteristic to particular frequencies of light.

Implementations of the invention may include the following features. The surface may include antennas configured to interact with selected frequencies of light, or the surface may be a surface of an interference cavity. The impedance characteristic may be reflection of particular frequencies of light, or transmission of particular frequencies of light. Each of the modulation elements may be an interference cavity that is deformable to alter the cavity dimension. The interference cavity may include a pair of cavity walls (e.g., mirrors) separated by a cavity dimension. One of the mirrors may be a broadband mirror and the other of the mirrors may be a narrow band mirror. Or both of the mirrors may be narrow band mirrors, or both of the mirrors may be broad band, non-metallic mirrors. The cavity may have a cavity dimension that renders the cavity resonant with respect to light of the frequency defined by the spectral characteristics of the mirrors and intrinsic cavity spacing in an undeformed state. One of the mirrors may be a hybrid filter. One (or both) of the walls may be a dielectric material, a metallic material, or a composite dielectric/metallic material. The cavity may be deformable by virtue of a wall that is under tensile stress. The control circuitry may be connected for analog control of the impedance to light of each element. The analog control may be control of the degree of deformity of the deformable wall of the cavity.

The predetermined impedance characteristic may include reflection of incident electromagnetic radiation in the visible spectrum, e.g., the proportion of incident electromagnetic radiation of a given frequency band that is, on average, reflected by each of the modulation elements. The modulation element may be responsive to a particular electrical condition to occupy either a state of higher reflectivity or a state of lower reflectivity, and the control circuitry may generate a stream of pulses having a duty cycle corresponding to the proportion of incident radiation that is reflected and places the modulation element in the higher state of reflectivity during each the pulse and in the lower state of reflectivity in the intervals between the pulses. The characteristic may include emission of electromagnetic radiation in the visible spectrum. The characteristic may include the amount of electromagnetic radiation in the visible spectrum that is emitted, on average, by the antennas. The characteristic may be incident electromagnetic radiation in the visible spectrum. The modulation elements may include three sub-elements each associated with one of three colors of the visible spectrum. The modulation element may be responsive to a particular electrical condition to occupy either a state of higher transmissivity or a state of lower transmissivity, and the control circuitry may generate a stream of pulses having a duty cycle corresponding to the proportion of incident radiation that is transmitted and places the modulation element in the higher state of transmissivity during each the pulse and in the lower state of transmissivity in the intervals between the pulses. The characteristic may include the proportion of incident electromagnetic radiation of a given frequency band that is, on average, transmitted by each of the modulation elements.

The visible spectrum may include ultraviolet frequencies, or infrared frequencies.

In general, in another aspect of the invention, the control circuitry may be connected to the array for controlling the amplitude of light delivered by each of the modulation elements independently by pulse code modulation.

In general, in another aspect, the invention features a modulation element having a deformable portion held under tensile stress, and control circuitry connected to control the deformation of the deformable portion.

Implementations of the invention may include the following features. The modulation element may be self-supporting or held on separate supports. The deformable portion may be a rectangular membrane supported along two opposite edges by supports which are orthogonal to the membrane. The deformable portion, under one mode of control by the control circuitry, may be collapsed onto a wall of the cavity. The control circuitry controls the deformable portion by signals applied to the modulation element, and the deformation of the control portion may be subject to hysteresis with respect to signals applied by the control circuitry.

In general, in another aspect, the invention features modulating light in the visible spectrum using a deformable modulation element having a deformation mechanism and an optical portion, the deformation mechanism and the optical portion independently imparting to the element respectively a controlled deformation characteristic and a controlled modulation characteristic.

Implementations of the invention may include the following features. The deformation mechanism may be a flexible membrane held in tensile stress, and the optical portion may